

## SECTION 34 21 18

### AC SWITCHGEAR, SEALED VACUUM TYPE

#### PART 1 –GENERAL

##### 1.01 SECTION INCLUDES

- A. General
- B. Operating requirements
- C. Ratings
- D. Switchgear enclosure
- E. Circuit breakers
- F. Buses and bus connections
- G. Grounding
- H. 125 Volt DC control power
- I. 120 Volt AC power
- J. Terminations
- K. Equipment protection
- L. Instrument transformers
- M. Appurtenances and auxiliary devices
- N. Maintenance accessories
- O. Factory testing
- P. Traction power facility system factory functional testing
- Q. Field acceptance testing

##### 1.02 RELATED SECTIONS

- A. Refer to the following Sections for requirements:
  - 1. Section 01 33 00 Submittal Procedures
  - 2. Section 01 33 23 Shop Drawings, Product Data, and Samples
  - 3. Section 01 45 24 Testing Program Requirements

4. Section 01 78 23      Operation and Maintenance Data
5. Section 01 78 44      Spare Parts and Maintenance Data
6. Section 34 21 05      Prefabricated AC and DC Equipment Houses
7. Section 34 21 33      Control, Monitoring and Display Panel
8. Section 34 21 40      DC Control Power System
9. Section 34 21 50      Common Materials and Methods for Traction Power
10. Section 34 21 75      Traction Power Facility System Factory Functional Testing
11. Section 34 21 80      Traction Power System Field Acceptance Testing
12. Section 34 22 23      Traction Power Cables

### **1.03      MEASUREMENT AND PAYMENT**

- A.      Measurement: AC switchgear will be measured for payment for each unit that is tested and furnished in accordance with the Contract Specifications.
- B.      Payment: AC switchgear will be paid for at the Contract unit price for each unit as indicated in the Bid Schedule of the Bid Form.

### **1.04      REFERENCES**

- A.      American Society for Testing and Materials (ASTM):
  1. ASTM F855      Standard Specification for Temporary Protective Grounds to be used on De-energized Electric Power Lines and Equipment
- B.      Institute of Electrical and Electronics Engineers (IEEE):
  1. IEEE C37.010      Application Guide for AC High Voltage Circuit Breakers > 1000 VAC Rated on a Symmetrical Current Basis
  2. IEEE C37.04      Standard Rating Structure of AC High-Voltage Circuit Breakers
  3. IEEE C37.06      Standard for AC High-Voltage Circuit Breakers Rated on Symmetrical Current Basis-Preferred Ratings and Related Required Capabilities for Voltages Above 1000V
  4. IEEE C37.09      Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
  5. IEEE C37.20.2      Standard for Metal-Clad Switchgear

- 6. IEEE C37.20.4      Standard for Indoor AC Switches (1 kV to 38 kV) for Use in Metal-Enclosed Switchgear
- 7. IEEE C57.13      Standard Requirements for Instrument Transformers
- C. National Electrical Manufacturers Association (NEMA):
  - 1. NEMA SG 4      Alternating Current High Voltage Circuit Breakers
  - 2. NEMA/ANSI C37.51      For Switchgear – Metal-Enclosed Low-Voltage AC Power Circuit Breaker Switchgear Assemblies – Conformance Test Procedures
  - 3. NEMA/ANSI C37.55      American National Standard for Switchgear – Medium Voltage Metal-Clad Assemblies – Conformance Test Procedures
- D. National Electrical Safety Code (NESC):
  - 1. IEEE/ANSI C2      National Electrical Safety Code
- E. National Fire Protection Association (NFPA):
  - 1. NFPA 70      National Electrical Code

## 1.05 SUBMITTALS

- A. General: Refer to Section 01 33 00, Submittal Procedures, and Section 01 33 23, Shop Drawings, Product Data, and Samples for submittal requirements and procedures.
- B. Product Data: Submit product data for components specified herein.
- C. Design Drawings: Provide design drawings for the 34.5 kV switchgear and associated devices, including equipment layouts and circuit breaker control schematics.
- D. Protective relay settings software and C02 panel PLC software ladder logic diagrams.
- E. Test plan and procedures for factory testing.
- F. Test report for factory testing.
- G. Operation and Maintenance Manuals: Provide systems manuals with operation and maintenance manuals in accordance with Section 01 78 23, Operation and Maintenance Data.
- H. Record drawings.
- I. Equipment and software configuration control logs.

**1.06 QUALITY ASSURANCE**

- A. Electrical components, devices, and accessories shall be listed and labeled in conformance with NFPA 70, Article 100.
- B. The manufacturer of the 34.5 kV AC switchgear and 34.5 kV circuit breakers shall have a minimum of 5 years of successful and proven transit, industrial or utility experience in providing equipment similar to the one specified herein.
- C. The manufacturer of the AC switchgear's auxiliary equipment, devices and components shall have a minimum of five years of successful and proven design and manufacturing experience in the transit industry, providing equipment similar to the one to be furnished under this Contract.

**1.07 DELIVERY, STORAGE AND HANDLING**

- A. Equipment shall be weatherproofed for shipment. Connection openings shall be closed to prevent entrance of foreign material during shipment and storage.
- B. Equipment shall be handled and stored in conformance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment.

**1.08 GENERAL REQUIREMENTS**

- A. Refer to Contract Specifications Section 34 21 01, General Requirements for the Traction Power System for general requirements.

**1.09 SPARE PARTS, TEST EQUIPMENT AND TOOLS**

- A. Mandatory Spare Parts: For each substation delivered, furnish the following mandatory spare parts to maintain and operate the 34.5 kV metal-clad type switchgear with the requirements of Section 01 78 44, Spare Parts and Maintenance Materials.
  - 1. Two Integrated Protection Relays (IPR) as described below
  - 2. One 34.5 kV circuit breaker as described below
  - 3. 10 percent spares of fuses, indication lights, and control power circuit breakers
- B. Recommended Spare Parts: Provide a recommended list of spare parts required to maintain and operate the facility power system in accordance with the requirements of Section 01 78 44, Spare Parts and Maintenance Materials.

## PART 2 – PRODUCTS

### 2.01 GENERAL

- A. The functions of the AC switchgear assembly in each traction power facility are as described below.
1. In switching stations, the 34.5 kV switchgear receives three-phase, 60 Hz, 34.5 kV power from the high-voltage 230, 115, 60/34.5 kV substation and distributes it by means of two 34.5 kV sub-transmission feeders to the traction power substations installed along the tracks, as indicated. In certain switching station locations, the AC switchgear is provided with an additional circuit breaker, which supplies power to auxiliary substations feeding the subway ventilation system.
  2. In Traction Power Substations (TPSS), the 34.5 kV switchgear receives power from the two sub-transmission feeders and distributes it to two transformer rectifier units via sectionalized bus. Each 34.5 kV feeder is terminated on the line side of a circuit breaker, whose load side is connected to a rectifier transformer. A normally open bus-tie circuit breaker is provided, also connected between the load sides of the two feeder circuit breakers. The feeder circuit breakers are normally closed.
  3. In sectionalizing stations, the AC switchgear divides the 34.5 kV sub-transmission system between adjacent high-voltage substations into line sections and provides the capability to connect the two adjoining line sections during outage of either high-voltage substation.
- B. The AC switchgear shall form a lineup of dead-front, free standing sheet metal cubicles. The AC switchgear and associated auxiliary cubicles shall be of the metal-clad construction, and designed and fabricated in accordance with IEEE C37.20.2 and NEMA C37.51.
- C. The AC switchgear shall be housed in an outdoor, walk-in type, transportable prefabricated house, as specified in Section 34 21 05, Prefabricated AC and DC Equipment Houses, or in an equipment room located within a passenger station or other facility. The AC switchgear shall include draw-out circuit breakers, three-phase bus and bus connections, cable terminations, instrument transformers, indicating devices, protective and auxiliary relays, terminal blocks, control circuitry, interlocks, switches, and all other equipment, panels, and devices as indicated for a complete operating installation.

### 2.02 OPERATING REQUIREMENTS

- A. The 34.5 kV circuit breakers shall be provided with both local and remote control, and monitoring.
- B. At the switching stations, the 34.5 kV circuit breakers shall be normally closed to keep both sub-transmission feeders energized under normal operating conditions.

- C. At the sectionalizing stations, the 34.5 kV circuit breakers shall be normally open.
- D. At each TPSS, operation of the circuit breakers shall be as follows:
  - 1. Under normal operating condition, the two 34.5 kV feeder circuit breakers shall be normally closed and the 34.5 kV bus tie circuit breaker shall be normally open. The line side of each feeder circuit breaker shall be connected to the incoming 34.5kV sub-transmission feeder and the load side connected to the rectifier transformer.
  - 2. The two 34.5 kV feeder circuit breakers and the bus tie circuit breaker shall be equipped with automatic transfer scheme (ATS) such that upon loss of power on either one of the incoming 34.5 kV sub-transmission feeders, after a programmable short time delay (as approved by the Engineer), it will automatically trip the affected 34.5 kV feeder circuit breaker and automatically close the normally open 34.5 kV tie circuit breaker. No paralleling of the two 34.5 kV feeder circuit breakers will be allowed and no automatic transfer will be permitted if there are any system faults (i.e., phase to phase or phase to ground or phase current unbalanced).
  - 3. During manual operation, the 34.5 kV feeder and the bus tie circuit breakers shall have the capability to operate with one feeder circuit breaker closed and the bus tie circuit breaker closed. Controls shall be designed to allow only two out of three circuit breakers to be closed at any one time.

## 2.03 RATINGS

- A. The AC switchgear ratings shall be in accordance with IEEE C37.06 and NEMA SG 4, and shall be as follows:
  - 1. Nominal Voltage, Line-to-Line: 34.5 kV, rms
  - 2. Rated Max Voltage: 38 kV, rms
  - 3. Rated Low Frequency Withstand: 80 kV, rms
  - 4. Rated Full Wave Impulse Withstand: 150 kV, rms
  - 5. Rated Frequency: 60 Hz
  - 6. Rated Continuous Current: 1200 A, rms
- B. AC circuit breakers shall be rated in accordance with IEEE C37.06 and NEMA SG 4 and shall have the following minimum ratings:
  - 1. Rated Short-Circuit Current at Rated Max kV: 21 kA, rms
  - 2. Breaker Rated Voltage Range Factor, K: 1.65
  - 3. Breaker Rated Interrupting Time: 5 cycles

4. Breaker Rated 3-Sec Short-Time Current Carrying Capability: 35 kA, rms
5. Breaker Rated Closing and Latching Capability: 95 kA, rms
6. Rated Max Voltage: 38 kV

## **2.04 SWITCHGEAR ENCLOSURE**

- A. Switchgear assemblies for circuit breakers and associated instrument transformers and relaying shall be of the metal-clad type and shall form a line-up of dead-front, freestanding cubicles. Each cubicle shall consist of several compartments to house the circuit breaker, bus bars, cables, relays and devices as indicated. Circuit breakers shall be installed in the bottom compartments of the respective cubicles.
- B. Each cubicle shall be a rigid, self-supporting, self-contained, electrically welded or bolted steel structure enclosing all sides and top, except openings for specific purposes. The structure shall support equipment under normal and short-circuit conditions.
- C. Panels comprising the switchgear enclosure, including the doors, shall be constructed of sheet steel, of thickness not less than No. 11 gauge.
- D. Compartments shall be isolated from one another by grounded barriers of not less than No. 11-gauge sheet steel.
- E. Each cubicle shall have front and rear hinged doors. Rear doors shall be weatherproof type. At a minimum, the doors shall meet the following requirements:
  1. The doors shall support flush and semi-flush mounted devices and not distort from a plane surface in any position. The doors shall be supported by concealed hinges.
  2. Each cubicle front hinged door shall have a handle and a mechanical three-point vibration-proof latch for holding it in a closed position.
  3. Each cubicle front door shall be provided with a stop to hold the door in the open position, such that door-mounted devices will not touch similar devices mounted on adjacent doors.
  4. Doors of the circuit breakers compartments shall be designed to be closed and locked when the breaker is in the CONNECTED, TEST or DISCONNECTED position.
  5. Both the front and rear doors shall have provisions for padlocking.
- F. Each circuit breaker cubicle shall be provided with protective shutters that automatically close and cover the live high-voltage terminals, as the removable breaker element is racked out.

- G. Breaker compartments shall be constructed so that the circuit breakers may be drawn in and out of their housing on wheels, along guide ways, and make connections to the buses and auxiliary circuits by means of self-aligning, self-coupling primary and secondary disconnecting devices.
- H. Bus compartments shall be of rigid framework and shall include bus work, connection bars, cable terminal connectors, bus and cable supports.
- I. To facilitate cleaning and inspection, removable cover plates with lifting handles shall be provided for bus compartments to allow access to the bus and cable connections with cables in place. Plates shall be metallic, shall be less than 18 by 24 inches in size, shall have no sharp edges, and shall weigh less than 20 lbs. each.
- J. Provide bottom cable entrance for external power and control terminations, unless top entries are shown on the Contract Drawings. At indoor TPSS, cable entrance shall be top entry. Ample space shall be provided for cable pulling, cable termination and performing high potential tests on cables without having to remove the terminations from the cubicle.
- K. Switchgear assembly items requiring inspection, operation or maintenance shall be installed no higher than 72 inches off of the floor, and shall be accessible from the front and back end of the switchgear.
- L. The switchgear cubicle shall contain louvers with filters preventing ingress of foreign particles and provide adequate ventilation and air cooling of the components inside. Louver design shall be coordinated with the specified ventilation system for the prefabricated switchgear house. Ventilation intake openings shall neither be located less than six inches above the floor, nor where they would allow entry of debris and dirt.
- M. The racking mechanism to move a circuit breaker between CONNECTED and TEST positions shall be accessible and operable with the front door closed and latched. When the breaker door is closed and the breaker is fully withdrawn, there shall be adequate electrical and mechanical clearance between the breaker and the door-mounted devices. A remote racking motor with a 20 foot long cable and control station shall be provided so that the breakers can be racked in or out electrically without requiring to stand in front of the breaker cubicle. Each breaker door shall have provision to mount the remote racking motor assembly. A receptacle to provide power for the motor shall be provided on each breaker cubicle door.

## 2.05 CIRCUIT BREAKERS

- A. General:
  - 1. The circuit breakers shall be sealed vacuum type, and shall be rated in accordance with IEEE C37.04 and IEEE C37.06. Circuit breaker design shall incorporate the following features:
    - a. The circuit breakers shall be three-pole, single-throw, stored-energy operating type, rated for service on a three-phase, effectively grounded-neutral, 60 Hz system at a nominal operating voltage of 34.5 kV line-to-line.



- b. The circuit breaker control circuits and stored-energy mechanism charging motor shall operate from a 125 V DC source.
  - c. Removable breaker elements of the same type and rating shall be completely physically and electrically interchangeable. Removable elements of different type or ratings shall not be interchangeable.
  - d. The circuit breakers shall close over a control voltage range from 90 V DC to 140 V DC, and trip over a control voltage range from 75 V DC to 140 V DC.
  - e. Each circuit breaker shall have a full front metal shield that will make it possible to access and maintain the operating mechanism from the front of the circuit breaker while it is installed in its cell. The circuit breaker frame shall be continuously grounded whenever it is installed in the cubicle by using a sliding contact on the circuit breaker that mates with a ground bar in the bottom of circuit breaker cell. The front metal shield shall serve to enclose the circuit breaker in its own grounded metal compartment when the circuit breaker is in the fully connected position.
2. Circuit breakers shall be designed to interrupt the rated short-circuit current in a sealed vacuum with a separate vacuum chamber for each phase of the circuit breaker:
- a. Contact erosion indication shall be provided on each interrupter pole assembly, for evaluation of wear on the main contacts over the life of the circuit breaker.
- B. Circuit Breaker Positions:
- 1. Provisions shall be made for moving the circuit breaker to and from a CONNECTED, TEST and DISCONNECTED position. The three positions shall be clearly marked on the floor of the switchgear cubicle cell, clearly visible through a viewing window.
  - 2. In the CONNECTED position, both the primary and secondary disconnecting devices shall be in full contact and the breaker shall be in position for normal operation.
  - 3. In the TEST position, the primary disconnecting devices shall be open and separated by a safe distance to prevent arcing, while the secondary disconnecting devices shall be in full contact. Automatically operated shutters shall cover the exposed part of the bus and main stationary contacts.
  - 4. In the DISCONNECTED position, both the primary and secondary disconnecting devices shall be open and separated by a safe distance.
- C. Operating Mechanism:
- 1. The circuit breaker shall be operated by a motor charged stored-energy mechanism, and shall be spring type, mechanically and electrically trip-free, and non-pumping. Circuit breaker design shall include provisions for manual charging of the stored-energy mechanism. The use of hydraulic or pneumatic operating mechanisms is not acceptable.

2. The operating springs shall discharge automatically when the breaker is rolled out fully from the compartment or is moved into the DISCONNECT position.
3. A closing spring CHARGE/DISCHARGE indicator shall be provided visible on the front of the removable element with the door closed, showing the status of the closing spring.
4. The closing spring shall be recharged automatically once the circuit breaker has been closed.

D. Withdrawal Mechanism:

1. Each switchgear cubicle shall have a cranking or ratcheting device for moving the circuit breaker to and from the CONNECTED, TEST and DISCONNECTED positions.
2. A switch shall be included to disconnect automatically the charging motor circuit during cranking.
3. Guide rails shall ensure alignment of the circuit breaker during insertion and removal. Breaker insertion and withdrawal shall be free of jamming and shall only require an average person to operate.

E. Mechanical Interlocks:

1. Mechanical interlocks shall be provided on each circuit breaker unit to:
  - a. Prevent inserting or disconnecting a closed circuit breaker
  - b. Discharge the stored energy springs prior to circuit breaker removal, and
  - c. Prevent the circuit breaker from closing, if the closing spring is not fully charged.
2. Positive stop shall be provided to prevent over travel of the circuit breaker when moving into the CONNECTED position and the TEST positions.
3. A flag indicator, visible when the cubicle door is closed, shall be provided to indicate when the breaker is in TEST or CONNECTED positions.

F. Disconnecting Devices:

1. Each circuit breaker shall be equipped with primary and secondary disconnecting devices.
2. Stationary and potentially energized parts of the primary disconnecting devices shall be covered automatically by safety shutters, when the circuit breaker is racked away from the CONNECTED position to the TEST or DISCONNECTED position. The shutters shall be operated by direct mechanical linkage to the floor-mounted racking mechanism, and shall be capable of withstanding the force of the circuit breaker in case of failure of the shutters to open when the breaker is racked into position. The shutters shall be designed to remain closed until they are opened by the presence of the circuit breaker.

3. Primary disconnecting devices shall:
  - a. Provide electrical continuity between the stationary contacts in the housing and the corresponding circuit breaker terminals.
  - b. Be located and mounted to maintain alignment during breaker insertion or withdrawal, and
  - c. Have silver-plated contact surfaces.

G. Circuit Breaker Controls:

1. A control switch shall be provided on the front door of each breaker unit for electrical tripping of the breaker in any position, and closing it only in the TEST position.
2. A LOCAL-REMOTE selector switch shall be provided on the front door of each breaker unit for electrical closing of the breaker in the connected position. When using this function, the close shall be actuated with a programmable time delay.
3. For traction power substations: Manual local control of the breaker shall be capable when the C02 LOCAL-REMOTE selector switch is in the LOCAL position and the AC breaker is in the CONNECTED position. Local control shall be capable of operating circuit breakers when the C02 main PLC or C04 Ethernet switch is inoperable.
4. For switching and sectionalizing stations: Manual local control shall be capable when the C02 LOCAL-REMOTE selector switch is in the LOCAL position and the AC breaker is in the CONNECTED position. Local control shall be capable of operating circuit breakers when the C02 main PLC or C04 Ethernet switch is inoperable.
5. For switching and sectionalizing stations, an input and output (I/O) module shall be installed in the C02 panel and the other of the matching pair shall be installed with the AC switchgear lineup. I/O module may be wired directly to more than one AC circuit breaker IPR.
6. Provide each circuit breaker with a manually-operated mechanical means for tripping the circuit breaker when in the TEST and CONNECTED positions, and closing the breaker when in the TEST position only. When in the TEST position the circuit breaker shall be operable only from the control switch mounted on the cubicle door.
7. Design circuit breakers for remote control operation as specified in Section 34 21 33, Control, Monitoring and Display Panel. Remote commands shall be able to trip the breaker at all times while in the connected position, but shall be able to close it only when the LOCAL-REMOTE selector switch located at the C02 panel and the LOCAL-REMOTE selector switch (Local) on the front of each circuit breaker unit are in the REMOTE positions.

8. Controls for the 34.5 kV circuit breakers shall be interlocked with the rectifier doors in the TPSS, such that any door opening shall trip the main and tie circuit breakers connected to their respective transformer-rectifier unit. The protective relay logic and interlocking shall permit operation of the substation with one transformer-rectifier unit only, while the other unit is out-of-service due to fault or maintenance.
9. Provide remote SCADA indications to the Operations Control Center for the open position status, closed position status, and CONNECTED/TEST/DISCONNECTED position for each 34.5 kV circuit breaker and Remote indications of both local and station selector switches.
10. A minimum of ten electrically separate reversible auxiliary spare contacts shall be provided, in addition to those required for the circuit breaker control circuit.
11. Auxiliary contacts external to the circuit breaker (MOC) shall be operated by the breaker mechanism in both the CONNECTED and the TEST positions.
12. Auxiliary contacts including spares shall be wired to the terminal blocks and properly labeled.
13. Six-digit operation counter shall be provided to record tripping operations.
14. Circuit breakers shall be equipped with padlocking provisions in the DISCONNECTED position.

H. Circuit Breaker Status Indications:

1. The open and close status of the breakers shall be indicated, respectively, by green and red lights mounted on the control panels and by mechanical flag indicators:
  - a. The red BREAKER CLOSED indicating light and auxiliary relay for remote indication shall be connected to monitor the continuity of the trip circuit.
  - b. The indicating lights and the mechanical flags shall be visible when the circuit breaker compartment door is closed.
2. A flag indicator, visible when the door is closed, shall be provided to indicate the position of the circuit breaker (i.e., CONNECTED, TEST or DISCONNECTED).
3. Dry auxiliary contacts mounted on the circuit breaker and wired to terminal blocks shall be provided for remote breaker status and position indications.

## 2.06 BUSES AND BUS CONNECTIONS

- A. The 34.5 kV buses shall be made of rigid copper bars and shall be of sufficient size to carry the continuous rated current, without exceeding the temperature limits indicated in IEEE C37.20.2. The continuous rating of bus and bus connections shall be 1200 amperes.

- B. The phasing of the power provided is counterclockwise, such that the A is 0 degrees, B is 240 degrees, and C is 120 degrees. The phase sequence of three-phase assembled buses and primary conductors shall be A-B-C counting from front to back, top to bottom, or left to right as viewed from the front side of the switchgear assembly.
- C. The buses shall be supported and braced between each other and to the enclosure with high strength anti-hygroscopic, flame-retardant, non-tracking insulators, so that the buses withstand the thermal and mechanical stresses due to maximum short-circuit currents equal to the maximum symmetrical interrupting and three-second short time current ratings of the circuit breaker protecting the bus.
- D. Bus bars including runbacks shall be insulated with track-resistant, flame-retardant epoxy coating. Bus joints shall be insulated with flexible or molded removable resin boots. The method of bus insulation and materials shall conform to IEEE C37.20.2.
- E. Bus joints and connections shall be of the bolted construction. They shall:
  - 1. Be acid-etched and plated with electro-deposited silver after buses have been bent or formed. Bending after the plating process will not be allowed.
  - 2. Be made with Belleville-type washers and high-strength, rust resistant steel bolts, such as cadmium-plated or galvanized. Bolt shall be capable of being properly torqued and locked in place.
- F. Bus joints shall have conductivity at least equal to that of the bus bars, and each joint shall be so clamped such that no loss of conductivity will occur during the life of the equipment.
- G. Access plates shall permit assembling of joints and inspection of bolted connections after installation of the bus enclosure.

## **2.07 GROUNDING**

- A. A copper ground bus with a symmetrical withstand current rating equal to that of the circuit breaker shall extend throughout the entire length of the switchgear assembly. Ground bus shall not be less than 1/4-inch by 2-inches in size.
- B. At least two 9/16-inch diameter holes at 1-3/4-inch centers shall be provided at each end of the bus.
- C. Provide grounding knobs on the ground bus and on each phase bus for safety grounding of the incoming 34.5 kV cables and phase buses. The grounding knobs shall be provided with removable insulated caps for the grounding device.
- D. The frame of each circuit breaker shall be grounded directly through a high-current ground contact shoe, when the circuit breaker is in the CONNECTED or TEST positions.

- E. Each cubicle shall be grounded directly to the ground bus. Cubicle doors and panels shall be provided with a flexible copper braid ground strap attached to the structure framing.
- F. Grounding connections shall be metal-to-metal, with any nonconductive coatings such as paint or lacquers removed to ensure solid electrical contact.
- G. The ground bus shall have provisions for connecting ground cables in each cubicle and at the ends of the switchgear lineup.

## **2.08 125 VOLT DC CONTROL POWER**

- A. Control power for circuit breaker closing and tripping functions, and for energizing control, indication, monitoring and protective devices shall be from the 125 V DC control power as specified in Section 34 21 40, DC Control Power System.
- B. A two-conductor AWG No. 6 or larger, 125 V DC control bus with a minimum 600 V insulation shall be provided for the full length of each switchgear assembly.
- C. The control bus shall:
  - 1. Run in a protective raceway,
  - 2. Terminate on a terminal block for connection to the power supply source; and
  - 3. Be tapped at each cubicle served and extended to the associated circuit breaker control compartment.
- D. Molded-case, thermal magnetic circuit breakers shall be provided for protection and isolation of each control circuit in each switchgear cubicle.
- E. Control power voltage-monitoring relay shall be provided and connected on the load side of the molded-case circuit breaker in each switchgear cubicle.

## **2.09 120 VOLT AC POWER**

- A. A 120 V AC, 60 Hz, No. 2 AWG or larger two-wire bus shall be provided for devices such as heaters, fans, lights, and receptacles.
- B. The AC bus shall:
  - 1. Extend for the full length of each switchgear assembly;
  - 2. Terminate on a terminal block for connection to an external power supply; and
  - 3. Be tapped in each switchgear cubicle for connections of space heaters, fans, lights and receptacles. Lighting circuits shall be independent from other circuits.

**2.10 TERMINATIONS**

- A. Unless otherwise indicated, power cables shall enter and leave the switchgear at the bottom. Provisions shall be made to accommodate the number of cables indicated.
- B. The bus connections for the 34.5 kV single-conductor power cables shall be coordinated with the size of the cable terminations and shall not be located lower than 24 inches above the switchgear floor if the power cables are entering from below.
- C. 34.5 kV power cable terminations shall be as specified in Section 34 22 23, Traction Power Cables. NEMA 2-hole cable connections shall be provided for the cable size indicated.
- D. Low voltage terminations shall be as specified in Section 34 21 50, Common Materials and Methods for Traction Power.

**2.11 EQUIPMENT PROTECTION**

- A. Relaying, metering and indicating devices shall be provided as indicated. Refer to Section 34 21 50, Common Materials and Methods for Traction Power, for general requirements of protective relays and indicating devices.
- B. Provide control and indication functions in accordance with Contract Specifications Section 34 21 33, Traction Power Control, Monitoring, and Display Panel and Related Equipment.
- C. Equip each 34.5 kV feeder circuit breaker and bus tie circuit breaker with a microprocessor-based multi-function protection relay, referred to as an IPR as specified in Section 34 21 12, Integrated Protection Relay Equipment for AC Circuit Breakers for High Voltage and Traction Power Substations; and Section 34 21 13, Integrated Protection Relay Equipment for AC Circuit Breakers for Switching Stations and Sectionalizing Stations.
- D. At traction power facilities using 34.5 kV switchgear, IPRs shall be used for protection and circuit breaker control. Provide protection functions as indicated.
- E. Overcurrent Protection:
  - 1. For switching and sectionalizing stations provide backup controls described in Article 2.05G.4 and 5 in addition to the primary control and protection devices. If an equipment or cable phase or ground fault occurs, the corresponding 34.5 kV feeder circuit breakers shall be tripped directly by primary or back-up protection devices, or through its corresponding lockout relay, device 286, as indicated on the Contract Drawings. If there is any failure in the fiber optic cable associated with the protection relay, the 34.5 kV circuit breakers 252-11, 252-12 and bus tie circuit breaker 252-13, or 252-3 and 252-4 shall be tripped through back-up remote I/O modules.

2. At traction power substations if a phase or ground fault occurs on a 34.5 kV transformer-rectifier circuit, the corresponding 34.5 kV feeder circuit breaker and 34.5 kV bus tie circuit breaker shall be tripped directly by its primary or back-up protection devices, or through its corresponding lockout relay, device 286, as indicated on the Contract Drawings.

F. Control and Communications Functions:

1. Coordinate the C02 panel to implement controls, indications, and data transfer between the IPR relays and the C02 panel for local and remote control, indication, and data transfer functions and processes. Communication between IPR relays and the C02 PLC shall use the DNP3 protocol.

## 2.12 INSTRUMENT TRANSFORMERS

- A. Instrument transformers shall conform to IEEE C57.13 and NEMA C12.11. The current and potential transformers shall comply with the ANSI/IEEE relays and metering accuracy standards, and shall have 0.6 accuracy class or better, under the burdens imposed by the connected services. This accuracy limit does not apply to revenue metering which is described below.
- B. Instrument transformers shall be insulated for 38 kV voltage class and shall have basic impulse insulation level of 200 kV full-wave.
- C. Current transformers (CTs) shall be dry type, of molded rubber or epoxy construction, multi-ratio, bushing, toroidal or wound-type:
  1. Ratio and phase-angle characteristics of CTs shall be suitable for the relaying or metering, as indicated.
  2. CTs shall be installed in a manner such that they are easily accessible for inspection and maintenance.
  3. In TPSSs and switching stations, each feeder and tie circuit breaker cubicle shall be provided with two CTs per phase rated 1200/5A. In sectionalizing stations, each circuit breaker cubicle shall be provided with one CT per phase rated 1200/5A as indicated.
  4. CTs and their secondary wiring shall be protected from induced voltages by metallic shielding. Secondary wiring shall utilize No. 10 AWG copper wire and shall be run to readily identifiable terminal blocks in the breaker control compartment. The terminal blocks for the CTs shall be suitable for ring type wire connections, shall have covers, and shall feature integral shorting bars for the CT leads.
  5. CTs shall be capable of withstanding thermal, magnetic and mechanical stresses from the flow of current equal to the interrupting and momentary routings of the circuit breakers.
  6. CTs for revenue metering or power monitoring applications shall be 0.15 percent across burden classes B1 through B8 as defined by IEEE C57.13.6.



- D. Potential transformers (PTs) shall be of the molded rubber or epoxy-encapsulated construction, with primary current-limiting fuses mounted on integral drawout carriage as indicated:
1. PTs shall be mounted in a dedicated compartment and shall be easily accessible for inspection and maintenance, either from the front or rear of the cubicle. Upon opening of the dead-front door, the primary fuses and PTs shall be automatically disconnected and shall be visibly grounded.
  2. Primary and secondary circuits of PTs shall be protected by means of non-renewable cartridge type fuses. Secondary circuit fuses shall be installed in the low voltage circuits of the PTs and shall be located such that it permits replacement when the switchgear is in service.
  3. PTs shall have voltage ratio of 20,125 V primary to 115 V secondary, and shall be connected between phase A and neutral, phase B and neutral, and phase C and neutral.
  4. PT disconnecting means shall use umbilical cord type disconnecting hardware. Minimum cord length shall be 36 inches.
  5. PTs for revenue metering application shall be 0.15 percent across burden classes W to ZZ as defined by IEEE C 57.13.6.

## **2.13 APPURTENANCES AND AUXILIARY DEVICES**

- A. AC switchgear appurtenances and auxiliary devices, such as control switches, wiring devices, low voltage wires and cables, and indicating lights shall be as specified in Section 34 21 50, Common Materials and Methods for Traction Power.

## **2.14 MAINTENANCE ACCESSORIES DEVICES**

Provide the following accessories for each AC switchgear assembly:

- A. Wall mounted test cabinet with necessary equipment for testing a 34.5 kV AC circuit breaker after it has been removed from the cubicle.
- B. Necessary equipment needed for the normal operation and preventive maintenance of the circuit breaker, such as manual charging handle and manual racking crank handle. One set of fuse tongs or hooksticks for replacement of high-voltage fuses, depending on the requirements.
- C. Test cable of minimum 6-feet in length for each switchgear assembly to permit operating a circuit breaker when completely removed from its compartment. This cable will be required to connect the control circuits of the compartment to the control circuits of the withdrawn breaker and to operate the breaker without the use of the test cabinet.
- D. One set of wrenches required for the primary disconnecting devices of the circuit breaker, and two sets of screwdrivers and other hand tools required for obtaining access to the AC switchgear and replacement of any equipment or device in the AC switchgear. Tools shall be insulated type.

- E. A cable-type grounding device for grounding dead bus of the switchgear. The device shall be operated by a hot-stick and shall meet ASTM F855 requirements. A wall-mounted storage panel shall be provided for the grounding device and the hot-stick.

## **2.15 FACTORY TESTING**

- A. General: Testing shall be performed in accordance with the requirements of Section 01 45 24, Testing Program Requirements.
- B. Factory Tests:
  - 1. The following design tests shall be performed on one AC switchgear assembly, complete with associated 34.5 kV AC circuit breakers:
    - a. Applicable tests identified as design tests in IEEE C37.09 for the circuit breaker.
    - b. Applicable tests identified as design tests in IEEE C37.20.2 and IEEE C37.55 for the switchgear assembly.
    - c. Performance verification tests on switchgear control circuits including automatic transfer.
  - 2. The following production tests shall be performed on AC switchgear assemblies, complete with their associated 34.5 kV AC circuit breakers:
    - a. Applicable tests identified as production tests in IEEE C37.09 for the circuit breakers.
    - b. Applicable tests identified as production tests in IEEE C37.20.2 and IEEE C37.55 for the switchgear assemblies.
    - c. Functional tests on switchgear control circuits including automatic transfer between the substation 34.5 kV main circuit breakers and bus tie circuit breaker.

## **2.16 TRACTION POWER FACILITY SYSTEM FACTORY FUNCTIONAL TESTING**

- A. Refer to Section 34 21 75, Traction Power Facility System Factory Functional Testing for requirements.

## **PART 3 – EXECUTION**

### **3.01 FIELD ACCEPTANCE TESTING**

- A. Refer to Section 34 21 80, Traction Power System Field Acceptance Testing for requirements.

**END OF SECTION 34 21 18**